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Variations in the composition of the human rectus sheath: a study of the anterior abdominal wall

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INTRODUCTION

"Descriptions of the rectus sheath contained in our textbooks of anatomy are singularly alike; they are stereotyped and oversimplified; when these accounts recognise structural variation at all it is only in connection with the position of the linea semicircularis." This was written over forty years ago (McVay & Anson, 1940) and since then it seems that little has changed. It was, however, a footnote in the 35th edition of *Gray's Anatomy* (Warwick & Williams, 1973) that drew our attention to the fact that despite the apparent accord in textbooks of anatomy, considerable variation in the disposition of the aponeuroses forming the rectus sheath has been reported over at least the last fifty years. This paper presents the results of a study of the constitution of the rectus sheath and associated musculature in embalmed and fresh postmortem cadavers, together with observations on the nerves of the anterior abdominal wall.

MATERIALS AND METHODS

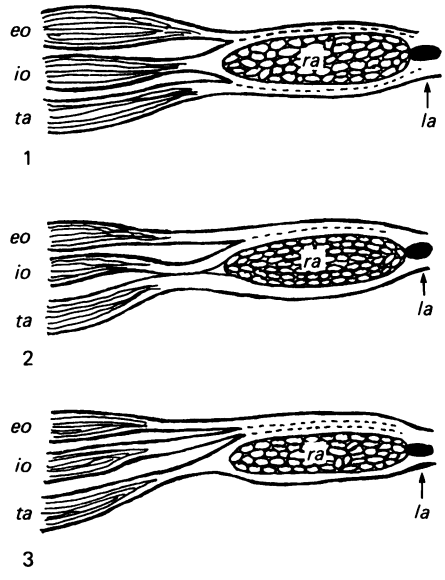
The investigation was performed on 9 embalmed and 31 fresh postmortem white European cadavers. A median skin incision was made and the overlying skin and subcutaneous tissues carefully removed, as far as possible leaving the abdominal nerves intact as they pierced the rectus sheath. The composition of the anterior wall of the sheath was noted after making a single paramedian incision on each side from the costal to the pubic attachments. The posterior wall was studied after removal of the rectus abdominis muscle. The position of the arcuate line and the incidence of the pyramidalis muscle were noted in these same 40 specimens, together with 16 more embalmed specimens which were unsuitable for study of the rectus sheath, making a total of 56 cadavers (112 sides).

RESULTS

The rectus sheath

The manner in which the aponeuroses of the abdominal muscles formed the rectus sheath was the same on both sides of each of the 40 cadavers.

In 24 out of 40 cases the composition of the rectus sheath above the arcuate line conformed to the classical textbook description, the aponeurosis of the internal oblique muscle splitting to enclose the rectus abdominis muscle, the aponeurosis of external oblique muscle remaining anterior and the aponeurosis of transversus abdominis muscle remaining posterior (Fig. 1).



Figs. 1–3. Diagrams showing the constitution of the rectus sheath. *eo*, external oblique; *io*, internal oblique; *ta*, transversus abdominis; *ra*, rectus abdominis; *la*, linea alba.

In 11 out of 40 cases the aponeurosis of transversus abdominis remained posterior to the rectus abdominis muscle, but the aponeurosis of internal oblique passed anterior. However, the muscles were firmly attached to each other, though not to the overlying aponeurosis of external oblique, at the lateral border of the rectus abdominis muscle. Both aponeurotic layers nevertheless retained their independence in that fibres in each could be traced back to their parent muscle (Fig. 2).

In the remaining 5 out of 40 cases the aponeurosis of transversus abdominis split around the rectus muscle, the aponeuroses of both external and internal obliques fusing with the anterior layer. The only layer separating rectus abdominis muscle from the transversalis fascia in these five specimens was, therefore, the posterior portion of the aponeurosis of transversus abdominis (Fig. 3).

Muscular fibres of transversus abdominis were present in the posterior layer of the sheath above the arcuate line in all cases. The accessory internal oblique muscle described by Chouke (1935) and later workers was not found in any specimen.

Below the arcuate line, the classical description held in that all three musculo-aponeurotic layers passed anterior to the rectus abdominis muscle. The aponeurosis of external oblique tended to remain separate from the underlying internal oblique and transversus abdominis, this being more noticeable nearer the pubis. The aponeurosis of external oblique, therefore, was mainly no more than a superficial covering of internal oblique; it contributed little to the rectus sheath itself except in the midline where it fused in the linea alba. The aponeuroses of internal oblique and transversus abdominis fused at or just medial to the lateral border of rectus abdominis muscle. This formed an entirely aponeurotic covering of rectus abdominis muscle in only 17 out of 40 cases; muscular fibres of transversus abdominis were present in 13 cadavers, muscular fibres of internal oblique in 6, and muscular fibres of both transversus abdominis and internal oblique in 4 cases.

Table 1. *The position of the medial and lateral extremities of* 112 *arcuate lines from* 56 *cadavers*

	mean (range) (mm)
Vertical distance of medial end of 112 arcuate lines:	
Above the pubic crest	63 (30–126)
Below the umbilicus	48 (16–95)
Vertical distance of lateral end of 112 arcuate lines:	
Above the pubic crest	87 (46–130)
Below the umbilicus	65 (30–112)

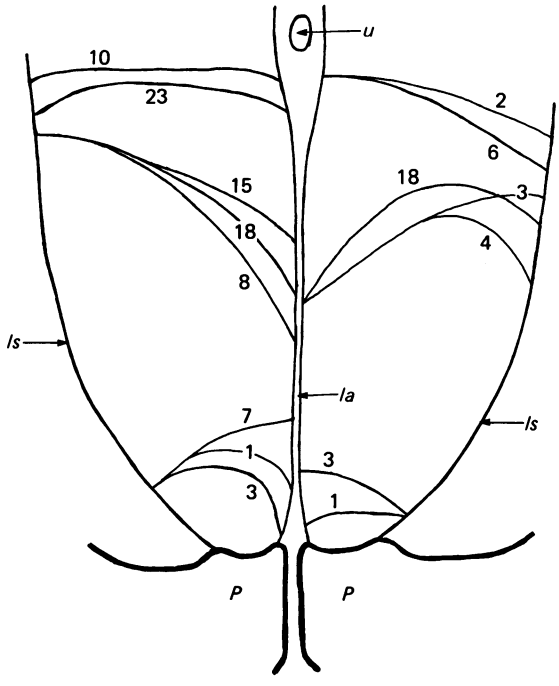


Fig. 4. Diagram showing incidences, positions and variations in the shape of 112 arcuate lines from 56 cadavers. Right and left sided lines are shown only for diagrammatic convenience and do not necessarily reflect right and left sided lines in the specimens. Numbers indicate the incidence of lines in the position shown, relative to the umbilicus and the pubic crest (total number: 112). *u*, umbilicus; *la*, linea alba; *ls*, linea semilunaris; *P*, pubis.

The arcuate line

The position of the arcuate line was very variable. The summit of the line was on some occasions as high as the umbilicus and on others almost at the pubic bone, thus forming little more than a foramen for the passage of the inferior epigastric vessels. The medial end was usually lower than the lateral; a symmetrical disposition was a rarity. Details of the positions and shapes of the lines are given in Table 1 and Figure 4.

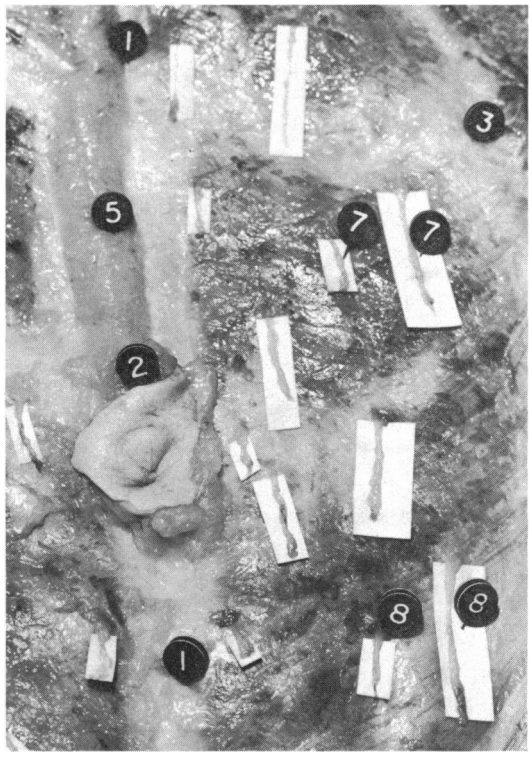


Fig. 5. Dissection of nerves emerging through the anterior abdominal wall of an embalmed specimen. 1, linea alba; 2, umbilicus; 3, aponeurosis of external oblique; 5, undissected superficial fat above umbilicus; 7, 8, cutaneous branches of identifiable intercostal nerves. The segmental origin of other nerves was not identifiable by gross dissection.

Pyramidalis muscle

The incidence of the pyramidalis muscle was noted in 56 cadavers (112 sides). In only one case did the muscle occur bilaterally and in only two more was it unilateral, both of these being right sided.

Nerves

It was noted that the cutaneous nerve supply over the rectus abdominis muscle and the nerve supply of the muscle itself were not arranged on any strictly segmental basis. There was a plexiform arrangement of the segmental nerves deep to the internal oblique muscle. This involved particularly the main trunks and collateral branches of intercostal nerves T9–T11 (inclusive). Intercostal nerves T7, T8 and T12 were less often involved and these nerves were most often free of communicating branches from other nerves. These connections with neighbouring nerves were not confined to any particular region; some were situated lateral to the linea semilunaris, in some cases involving the main nerve trunks, and others were seen after the nerves had pierced the rectus sheath. There was considerable overlap in the rectus abdominis muscle itself between adjacent (and, because of this plexiform arrangement, presumably already segmentally mixed) nerves; the arrangement of cutaneous branches emerging anteriorly from the rectus abdominis muscle was apparently random (Fig. 5), the segmental origin rarely being identifiable with confidence.

DISCUSSION

These findings challenge those of McVay & Anson (1940) who reported the classical description of the rectus sheath in only 2 out of their 56 specimens. The disposition they most commonly noted was the division of the aponeurosis of transversus abdominis to enclose rectus abdominis muscle, which in the present study occurred in only 5 out of 40 cases (Fig. 3). The second most frequent arrangement in the present study (Fig. 2) was one of those noted by Walmsley (1937) and his view that "the external oblique aponeurosis is not a true part of the rectus sheath but a superficial covering of it" is also reinforced by the present study, in particular below the arcuate line.

Chouke (1935) was the first to describe an accessory internal oblique muscle, posterior to the main internal oblique, originating by fleshy fibres from the iliac crest. He reported that its aponeurosis was inserted into the linea alba after fusing with that of transversus abdominis. He gave its dimensions as 2–3 inches wide and similar in thickness to the main internal oblique muscle. It was always separated from the main internal oblique muscle by branches of the iliohypogastric nerve and the deep circumflex iliac artery. In his study of 136 cadavers he found complete absence of this accessory internal oblique muscle to occur only 4 times; not once in the present study of 56 cadavers was its presence ever noted despite diligent searching. Anson & McVay (1938) and Anson, Morgan & McVay (1960) also observed that the accessory internal oblique muscle was a significant structure, although the incidence in both these studies was less than that reported by Chouke.

The incidence of pyramidalis muscle, likewise, was in this study much lower than in others. Chouke (1935) reported an absence of pyramidalis in over 22 % of 123 cadavers, and Beaton & Anson (1939) reported it as absent on one or both sides in 20·3 % of Whites, and in 12·5 % of Negroes. In the present study, the absence of pyramidalis in most cadavers is clearly surprising.

The description given in the present study of the cutaneous and muscular branches of the segmental nerves reflects the findings of previous workers (Davies, Gladstone & Stibbe, 1931). It indicates that the segmental cutaneous innervation over particular areas (for example T10 over the umbilicus) is almost certainly more variable than may have been thought: it may be prudent to warn of this variation. In addition, there would appear to be no grounds for supposing (as has been supposed in the past) that the tendinous intersections of the rectus abdominis muscle in some way represent its primitive somatic derivation.

SUMMARY

Three modes of construction of the rectus sheath above the arcuate line were found in a study of 40 cadavers. The classical description occurred most frequently, in 24 cases. The other constructions conformed to those described in earlier studies although the incidences were different. The accessory internal oblique muscle was found in none of the 40 cadavers, and pyramidalis muscle occurred on one or both sides in only 3 out of 56 specimens. The shape and position of the arcuate line were neither symmetrical nor constant, and neither was the arrangement of the nerve supply to the rectus abdominis muscle or to the overlying skin.

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